Space Weather Technical Forecast

Issued on Monday, 20 March 2023 at 13:25 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of isolated M-flares throughout. Slight chance of G1/Minor Storm intervals with CME glance possible day 1 or 2 (20th or 21st). Chance of G1 increasing from late on day 3 (22nd) due to CH86/- moving into a geoeffective position.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with a single M1.3 flare observed at 20/0147 UTC from AR3256 in the southeast. This region is the largest and most complex sunspot region currently on the disc, and is classified Fho/Beta-Gamma. There are five other sunspot regions currently on the visible disc. Generally, these are unipolar and are either stable or showing some decay. However, AR3259 has shown some rudimentary penumbra development in its trailing group and is now classified Cri/Beta.

The M-flare had a drawn out X-ray signature and there was some dimming in the region of AR3256, but no CME has been observed in coronagraph imagery, and thus no Earth-directed CMEs have been observed in the last 24 hours.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured at L1, was slightly elevated at around 400-470 km/s, with density near or below average (2-10 ppcc). The total IMF strength Bt, was weak, around 5-7nT, with the north-south component Bz ranging between +5 to -6 nT. The phi angle was predominately positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES-16 is slightly above background, however this is still well below the S1/Minor Storm level and is exhibiting a flat trend. The high energy electron flux (greater than 2MeV) has generally been at background with the associated 24-hour Electron fluence below the Active (1e8 integrated pfu) threshold. At 20/0000 UTC the observed fluence was 5.4e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low activity is most likely, but with a chance of increasing to Moderate at times with isolated M-flares. These most likely from AR3256 or AR3259 in the southeast, or from other regions rotating over the eastern limb over the coming days.

Solar Wind / Geomagnetic Activity: A glancing CME impact is possible day 1 or early day 2 (20th or 21st) from the filament eruption from the southwest disc on 17 March, however this is low confidence. This will come alongside a muted connection to the fast wind from CH85/+ on day 1 (20th). A stronger fast wind connection is expected by day 4 (23rd) from CH86/- currently in the southeast, with Earth potentially encountering the CIR of this enhancement late on the day 3 (22nd).

Geomagnetic activity is expected to increase to Unsettled with Active intervals day 1 (20th), before easing again day 2 (21st) to become mostly Quiet. Perhaps increasing to Active, with a slight chance of G1/Minor Storm with any CME arrival late on day 1 (20th) and continuing into day 2 (21st). Any arrival of the CIR ahead of CH86/- on day 3 (22nd) will likely increase activity to Active with a chance of G1 Minor Storms, with these effects continuing into day 4 (23rd) as

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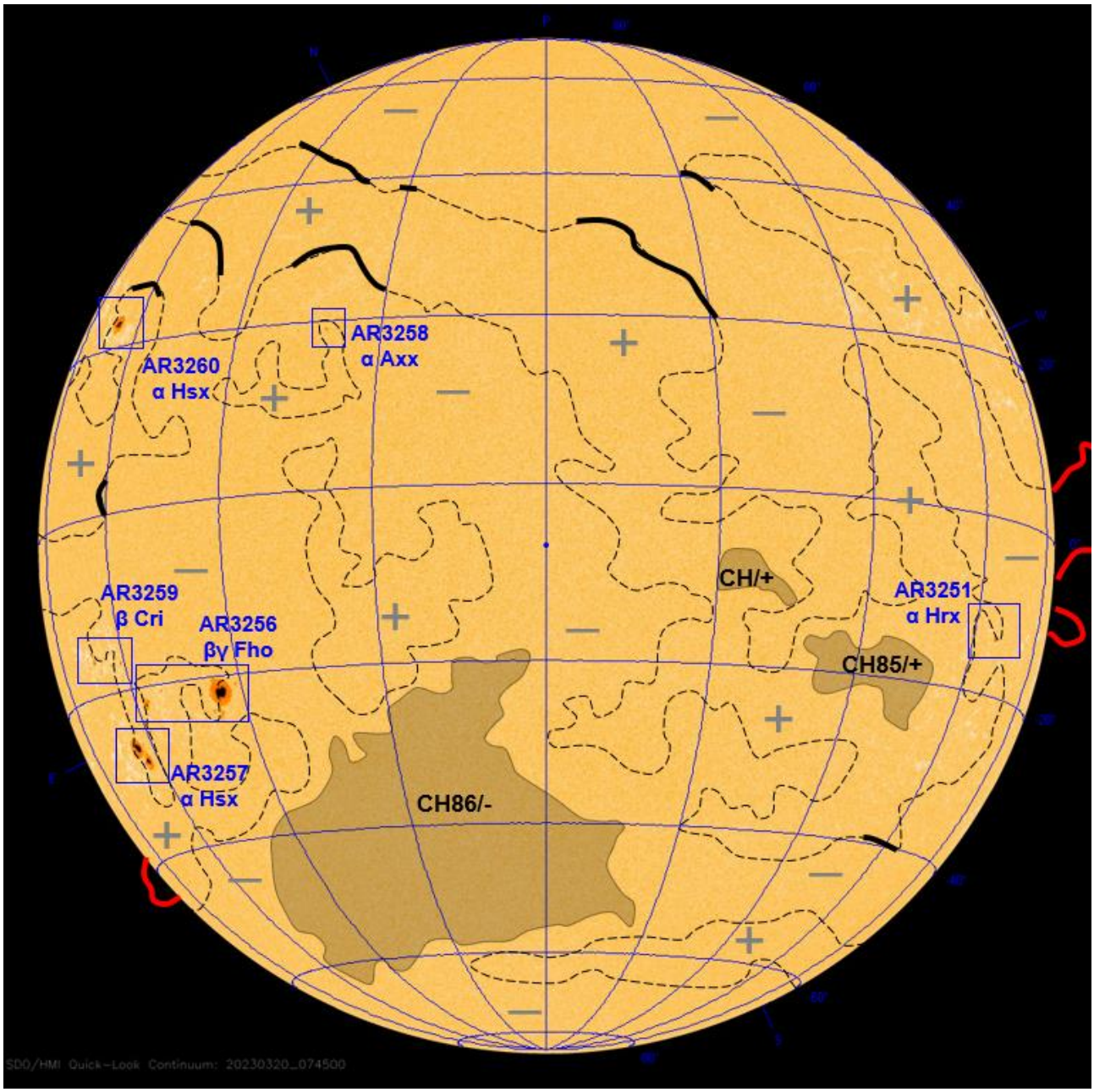
Earth enters the HSS from CH86/-.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is expected to decline to background, albeit erratically, with no further significant enhancements anticipated. The high energy electron flux is expected to persist largely at background, with a chance of rising to Moderate days 2 or 3 (21st or 22nd). The associated 24 hour fluence is expected to remain below the Active threshold.

Figure 1. Solar Analysis Valid 20/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME from 17 March has been assessed as passing mostly ahead and south of Earth, but with a chance of a glancing impact late on day 1 or early day 2 (20th or 21st). This is a low confidence forecast as coronagraph imagery is currently limited.
The fast wind associated with CH85/+ has the potential to bring some increased geomagnetic activity day 1 (20th) as Earth moves into its HSS. In the absence of any CME arrival this is likely to have a rather muted response, due to the Russel-McPherron effect, which results in positive features connecting less strongly near the March Equinox. However, alongside the low confidence CME, this gives a slight chance of activity increasing to G1/Minor storm later day 1 (20th).
CH86/-, currently approaching centre disc in the southern hemisphere, will then bring the next notable enhancement to the solar wind around Earth, with a likely arrival of a CIR region late on day 3 (22nd) or early day 4 (23rd). This arrival time is supported by Enlil and persistence, however the feature has both retreated eastwards but also become more defined and darker in imagery since the previous rotation. Elevated winds are likely, perhaps exceeding 600km/s, as supported by persistence.
Geomagnetic activity is expected to increase to Unsettled to Active, with any fast wind transition day 1 (20th), before easing days 2 and 3 (22nd and 23rd) to mostly Quiet again. Perhaps increasing to Active with a slight chance of G1/Minor storms with any CME arrival late on day 1 (20th) and continuing day 2 (21st). The arrival of the CIR of CH86/- on day 3/4 (22nd/23rd) will likely increase activity to Active with a chance of G1 Minor Storms, and the effects continuing for the rest of the period as Earth enters the HSS from CH86/-.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	20	30	40
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
17/1610	Partial	Filament	SW	510 km/s	20/2100 UTC +/- 9 hrs	Low confidence. Glancing impact most likely

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Figure 2: ENLIL ensemble

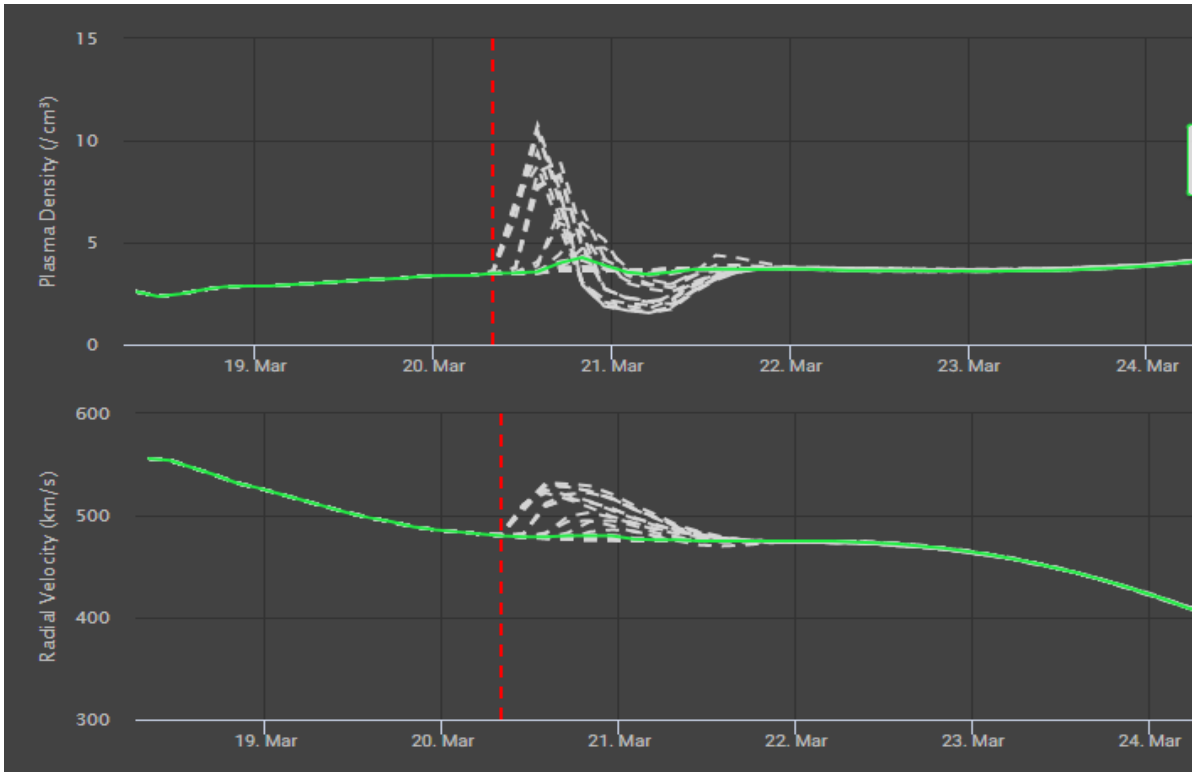

Figure 3: SDO AIA 211 last rotation (left) and current (right)

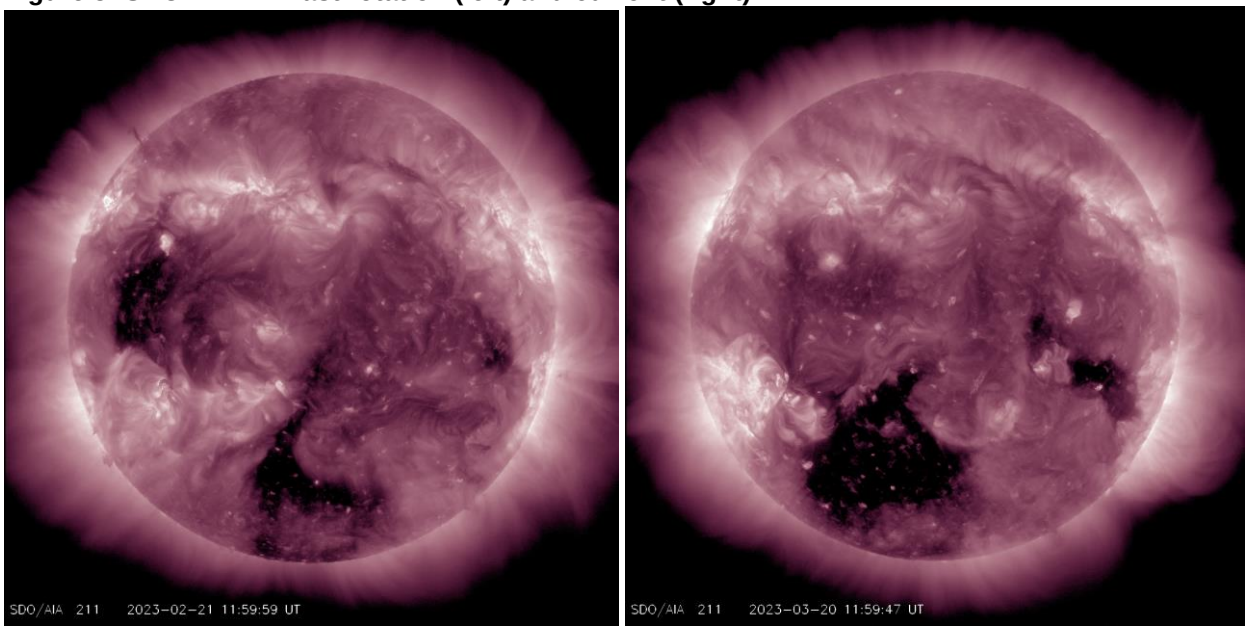

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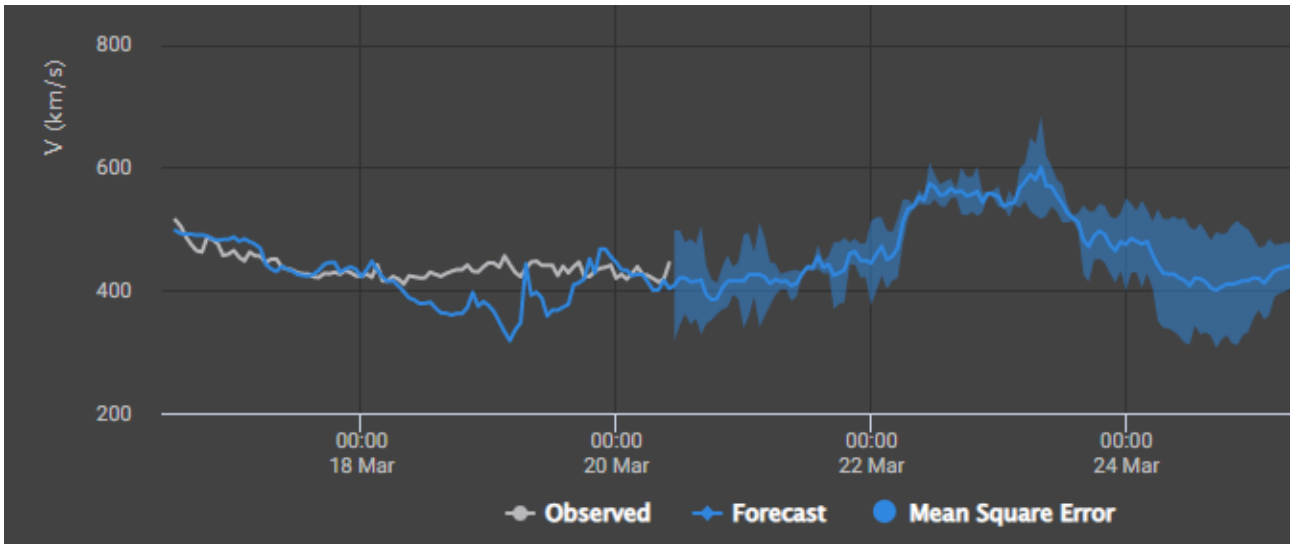
Figure 4: MOSWOC Solar Wind Persistence Model (SWPM)



Radio Blackouts - X-Ray Flares:

Solar activity is expected to be Low with a chance of rising to Moderate each day, due to the risk of isolated M-flares. There remains a slight chance of X-class flares, with the potential for further regions to rotate onto the eastern limb through the period.
Of the six sunspot regions on the visible disc AR3256 Fho/Beta-Gamma is the largest, comprising of a large leader region and a smaller trailer. Although this region is rather open, with good separation between spots, it does appear to have a degree of magnetic complexity, being in Beta-Gamma formation. AR3259, near the east limb, appears to be developing some rudimentary penumbra in its trailing portion and is now classified Cri/Beta. All other regions on the disc are unipolar and are currently stable or showing signs of decay.
There is also the potential for further regions to rotate onto the east limb, with significant looping visible on e.g. SDO aia-171, and far-side products such as Helioseismic images, showing a significant response to possible feature on the far-side. Therefore, there is a slight rising trend in the flare risk through the period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	25	30	40	40
Very Active	R3 to R5 X Class	No	1	5	5	5

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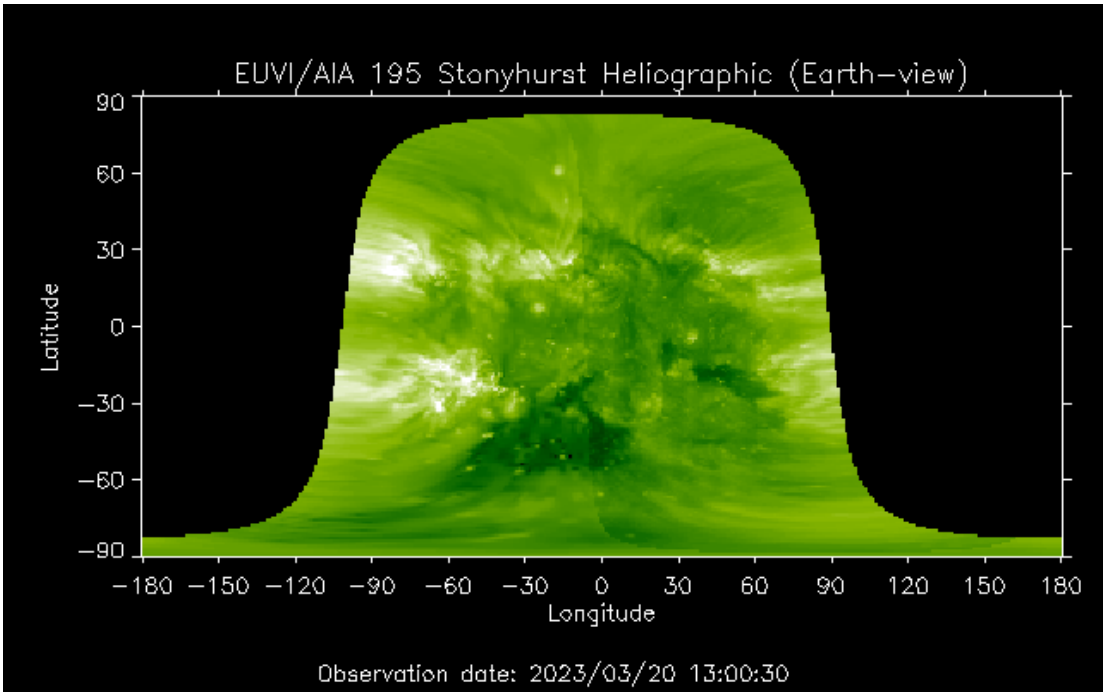
Figure 5: EUVI/AIA 195 heliographic, showing possible regions round east limb.



Solar Radiation Storms - (High Energy Protons):

High energy proton flux (greater than 10MeV), as observed by GOES-16 is currently slightly above background as it continues to erratically decline from the S1 Minor Radiation storm event triggered by the large far-sided eruption on the 14th. No further notable proton enhancements are currently anticipated, with the most notable sunspot regions in a less favoured position for connection to Earth should any significant flares occur.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	1	1	1	1
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2MeV) electron flux observed by GOES-16 is expected to be mainly background through the period. A modest increase is possible later day 2 and day 3 (21st and 22nd) due to any enhanced solar wind environment from the fast wind of CH85/+ or potential glancing CME impact, however this is low confidence. This may bring periods of Moderate flux, with only very slight chance of briefly reaching High levels. Any CIR arrival ahead of CH86/- on day 3 (22nd) will then likely result in flux levels dropping out again.
The associated 24 hour fluence is expected to be below the Active (1e8 integrate pfu) level with REFM currently giving good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	10	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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